IAP5 Rec'd PCT/PTO 28 SEP 2006

10/594637

DESCRIPTION

OPTICAL FILM AND IMAGE DISPLAY

Technical Field

[0001]

The invention relates to an optical film comprising a complex type scattering-dichroic absorbing polarizer and a birefringent film suitable for optical compensation caused by the retardation of a liquid crystal cell. The optical film may be used with any other optical film to form a laminate. The invention also relates to an image display using the optical film, such as a liquid crystal display, an organic electro-luminescent display, a CRT, and a PDP. In particular, the optical film of the invention is suitable for use in VA mode liquid crystal displays and can cut off light in a wide azimuth angle range between polarizing plates in the crossed Nicols arrangement and can produce high display quality with good viewing angles and good contrast.

Background Art

[0002]

Liquid crystal display are rapidly developing in market, such as in clocks and watches, cellular phones, PDAs, notebook-sized personal computers, and monitor for personal computers, DVD players, TVs, etc. In the liquid crystal display, visualization is realized based on a variation of polarization state by switching

of a liquid crystal, where polarizers are used based on a display principle thereof. Particularly, usage for TV etc. increasingly requires display with high luminance and high contrast, polarizers having higher brightness (high transmittance) and higher contrast (high polarization degree) are being developed and introduced.

[0003]

Conventionally, even through polarizing plates in the crossed Nicols arrangement can cut off light in the normal (front) direction by the regular functions of the transmission and absorption axes, there is a problem in which light leakage occurs in oblique viewing directions intersecting the optical axis and gradually increases as the oblique viewing angle increases. When polarizing plates are placed on both sides of a liquid crystal cell so as to function as a polarizer and an analyzer, respectively, to form a liquid crystal display, the problem leads to low display contrast due to the light leakage in oblique viewing directions deviating from the optical axis and manifests itself as a reduction in display quality.

[0004]

Therefore, a TN type liquid crystal cell or the like having a liquid crystal molecule homogeneously aligned with respect to the cell substrate can easily cause light leakage due to birefringence during transmission so that the display quality can easily be degraded. On the other hand, when a liquid crystal molecule is aligned substantially vertically to the cell substrate, light is transmitted almost without changing in the plane of polarization.

On the other hand, there is a vertical alignment (VA) mode liquid crystal cell, which can easily achieve light blockage in the front (normal) direction of the display panel vertical to the cell substrate and easily produce a good black viewing, during non-driving periods with no external voltage applied, when polarizing plates are placed in the crossed Nicols arrangement on both sides of the cell.

[0005]

It is known that biaxial birefringent films are useful for compensating for birefringence-induced retardation in VA type liquid crystal cells and widening the viewing angle for good visibility. In some biaxial birefringent films, three-dimensional refractive indices in the two in-plane directions and the thickness direction are controlled to provide the characteristic $nx \geq ny > nz$ (nx is with respect to the slow axis) so that Re and Rz are adjusted, wherein nx and ny are in-plane refractive indices, nz is a refractive index in the thickness direction, d is the thickness, $(nx-ny)d=Re$, and $\{(nx+ny)/2-nz\}d=Rz$ (hereinafter, these definitions are used in the same manner). In these biaxial birefringent films, Rz is particularly important, and the compensation in the VA type liquid crystal cells significantly depends on Rz. The conventional methods for producing the birefringent films include fixed-end uniaxial stretching methods in which one end is fixed, such as stretching in two directions (lengthwise and widthwise) and widthwise stretching through a tenter, and biaxial stretching methods (Japanese Patent Application Laid-Open (JP-A) No. 03-33719, JP-A No. 03-24502)

[0006]

However, the conventional methods have a problem in which an increase in stretch ratio for an increase in Rz leads to a reduction in the accuracy. In the biaxial stretching methods, Re and Rz are controlled by stretching temperatures and stretch ratios in the x and y directions, but an increase in Rz requires an increase in each of the stretch ratios in the x and y directions so that the accuracy of the optical axis, Re or Rz can be reduced due to the bowing phenomenon. In order to improve such methods, a polyimide resin or the like is developed on a supporting substrate and dried to form a transparent film in which $nx \approx ny$, and then the film is subjected to a stretching process or the like so that the above problem can be solved (JP-A No. 2003-315541).

[0007]

The above optical compensation leads to the achievement of high-contrast liquid crystal display elements, and thus good visibility has been further desired. Particularly in applications such as liquid crystal TVs, very-high-brightness backlights have come into use.

[0008]

Dichroic absorbing polarizers such as iodine based polarizers comprising stretched polyvinyl alcohol on which iodine is adsorbed are widely used, because they have high transmittances and high degrees of polarization (JP-A No. 2001-296427). However, iodine based polarizers have relatively low degrees of polarization on the

short wavelength side and thus have a problem with hue, such as blue dropout on the short wavelength side during black viewing and yellowing during white viewing.

[0009]

Iodine based polarizers can also easily suffer from uneven iodine adsorption. Such unevenness can be detected as uneven transmittance particularly during black viewing and cause the problem of a reduction in visibility. In order to solve the problem, for example, there are proposed a method in which the amount of iodine adsorbed on iodine based polarizer is increased such that the transmittance for black viewing does not exceed the lower limit of sensitivity of human eyes and a method employing a stretching process that is resistant to causing unevenness itself. However, the former method has a problem in which the transmittance for white viewing is also reduced in the same way as the transmittance for black viewing so that display itself becomes dark. The latter method also has a problem in which a certain process has to be entirely replaced so that the productivity can be reduced.

Disclosure of Invention

[0010]

It is an object of the invention to provide an optical film that comprises a laminate of an absorbing polarizer and a birefringent film, has a high transmittance and a high degree of polarization, can produce high contrast in a wide viewing angle range, and can

suppress unevenness in transmittance during black viewing.

[0011]

It is another object of the invention to provide an optical film comprising a laminate of the above optical film and at least one piece of any other optical film and to provide an image display using the optical film.

[0012]

As a result of examination wholeheartedly performed by the present inventors that the above-mentioned subject should be solved, it was found out that the above-mentioned purpose might be attained using optical films shown below, leading to completion of this invention.

[0013]

That is, this invention relates to an optical film comprising:

a complex type scattering-dichroic absorbing polarizer including a film that has a structure having a minute domain dispersed in a matrix formed of an optically-transparent water-soluble resin including an iodine based light absorbing material; and

a birefringent film including a transparent film formed of a solid polymer that having the characteristic nx>ny>nz, where a direction in which a refractive index in a film plane gives maximum is defined as X-axis, a direction perpendicular to X-axis as Y-axis, a thickness direction of the film as Z-axis, and refractive indices in each axial direction are defined as nx_1, ny_1, and nz_1, respectively.

[0014]

The minute domain of the complex type absorbing polarizer is preferably formed by an oriented birefringent material. The above-mentioned birefringent material preferably shows liquid crystallinity at least in orientation processing step.

[0015]

The above-mentioned polarizer of this invention has an iodine based polarizer formed by an optically-transparent water-soluble resin and an iodine based light absorbing material as a matrix, and has dispersed minute domains in the above-mentioned matrix. Minute domains are preferably formed by oriented materials having birefringence, and particularly minute domains are formed preferably with materials showing liquid crystallinity. Thus, in addition to function of absorption dichroism by iodine based light absorbing materials, characteristics of having function of scattering anisotropy improve polarization performance according to synergistic effect of the two functions, and as a result a polarizer having both of transmittance and polarization degree, and excellent visibility may be provided.

[0016]

Scattering performance of anisotropic scattering originates in refractive index difference between matrixes and minute domains. For example, if materials forming minute domains are liquid crystalline materials, since they have higher wavelength

dispersion of Δn compared with optically-transparent water-soluble resins as a matrix, a refractive index difference in scattering axis becomes larger in shorter wavelength side, and, as a result, it provides more amounts of scattering in shorter wavelength. Accordingly, an improving effect of large polarization performance is realized in shorter wavelengths, compensating a relative low level of polarization performance of an iodine based polarizer in a side of shorter wavelength, and thus a polarizer having high polarization and neutral hue may be realized.

[0017]

A combination of the complex type scattering-dichroic absorbing polarizer and a transparent film imparted the characteristic nx>ny>nz provides an polarizing plate with optical compensation function that has a high transmittance and a high degree of polarization, can produce high contrast in a wide viewing angle range, and can suppress unevenness in transmittance during black viewing.

[0018]

In the above-mentioned optical film, it is preferable that the minute domains of the complex type absorbing polarizer have a birefringence of 0.02 or more. In materials used for minute domains, in the view point of gaining larger anisotropic scattering function, materials having the above-mentioned birefringence may be preferably used.

[0019]

In the above-mentioned optical film, in a refractive index difference between the birefringent material forming the minute domains and the optically-transparent water-soluble resin of the complex type absorbing polarizer in each optical axis direction, a refractive index difference (Δn^1) in direction of axis showing a maximum is 0.03 or more, and a refractive index difference (Δn^2) between the Δn^1 direction and a direction of axes of two directions perpendicular to the Δn^1 direction is 50% or less of the Δn^1

[0020]

Control of the above-mentioned refractive index difference (Δn^1) and (Δn^2) in each optical axis direction into the above-mentioned range may provide a scattering anisotropic film having function being able to selectively scatter only linearly polarized light in the Δn^1 direction, as is submitted in U.S. Pat. No. 2123902 specification. That is, on one hand, having a large refractive index difference in the Δn^1 direction, it may scatter linearly polarized light, and on the other hand, having a small refractive index difference in the Δn^2 direction, and it may transmit linearly polarized light. Moreover, refractive index differences (Δn^2) in the directions of axes of two directions perpendicular to the Δn^1 direction are preferably equal.

[0021]

In order to obtain high scattering anisotropy, a refractive

index difference (Δn^1) in a Δn^1 direction is set 0.03 or more, preferably 0.05 or more, and still preferably 0.10 or more. A refractive index difference (Δn^2) in two directions perpendicular to the Δn^1 direction is 50% or less of the above-mentioned Δn^1, and preferably 30% or less.

[0022]

In iodine based light absorbing material in the above-mentioned optical film, a an absorption axis of the iodine based light absorbing material of the complex type absorbing polarizer is preferably orientated in the Δn^1 direction.

[0023]

The iodine based light absorbing material in a matrix is orientated so that an absorption axis of the material may become parallel to the above-mentioned Δn^1 direction, and thereby linearly polarized light in the Δn^1 direction as a scattering polarizing direction may be selectively absorbed. As a result, on one hand, a linearly polarized light component of incident light in a Δn^2 direction is not scattered or hardly absorbed by the iodine based light absorbing material as in conventional iodine based polarizers without anisotropic scattering performance. On the other hand, a linearly polarized light component in the Δn^1 direction is scattered, and is absorbed by the iodine based light absorbing material. Usually, absorption is determined by an absorption coefficient and a thickness. In such a case, scattering of light greatly lengthens an optical path length compared with a

case where scattering is not given. As a result, polarized component in the Δn^1 direction is more absorbed as compared with a case in conventional iodine based polarizers. That is, higher polarization degrees may be attained with same transmittances.

[0024]

Descriptions for ideal models will, hereinafter, be given. Two main transmittances usually used for linear polarizer (a first main transmittance k_1 (a maximum transmission direction = linearly polarized light transmittance in a Δn^2 direction), a second main transmittance k_2 (a minimum transmission direction = linearly polarized light transmittance in a Δn^1 direction)) are, hereinafter, used to give discussion.

[0025]

In commercially available iodine based polarizers, when iodine based light absorbing materials are oriented in one direction, a parallel transmittance and a polarization degree may be represented as follows, respectively:

parallel transmittance = $0.5 \times ((k_1)^2 + (k_2)^2)$ and

polarization degree = $(k_1 - k_2) / (k_1 + k_2)$.

[0026]

On the other hand, when it is assumed that, in a polarizer of this invention, a polarized light in a Δn^1 direction is scattered and an average optical path length is increased by a factor of α (> 1), and depolarization by scattering may be ignored, main

transmittances in this case may be represented as k_1 and $k_2' = 10^x$ (where, x is $\alpha \log k_2$), respectively

[0027]

That is, a parallel transmittance in this case and the polarization degree are represented as follows:

parallel transmittance = $0.5 \times ((k_1)^2 + (k_2')^2)$ and

polarization degree = $(k_1 - k_2') / (k_1 + k_2')$.

[0028]

When a polarizer of this invention is prepared by a same condition (an amount of dyeing and production procedure are same) as in commercially available iodine based polarizers (parallel transmittance 0.385, polarization degree 0.965: k_1 = 0.877, k_2 = 0.016), on calculation, when α is 2 times, k_2 becomes small reaching 0.0003, and as result, a polarization degree improves up to 0.999, while a parallel transmittance is maintained as 0.385. The above-mentioned result is on calculation, and function may decrease a little by effect of depolarization caused by scattering, surface reflection, backscattering, etc. As the above-mentioned equations show, higher value α may give better results and higher dichroic ratio of the iodine based light absorbing material may provide higher function. In order to obtain higher value α, a highest possible scattering anisotropy function may be realized and polarized light in a Δn^1 direction may just be selectively and strongly scattered. Besides, less backscattering is preferable, and a ratio of

backscattering strength to incident light strength is preferably 30% or less, and more preferably 20% or less.

[0029]

In the above-mentioned optical film, the films used as the complex type absorbing polarizer manufactured by stretching may suitably be used.

[0030]

In the above-mentioned optical film, minute domains of the complex type absorbing polarizer preferably have a length in a Δn^2 direction of 0.05 to 500 μm.

[0031]

In order to scatter strongly linearly polarized light having a plane of vibration in a Δn^1 direction in wavelengths of visible light band, dispersed minute domains have a length controlled to 0.05 to 500 μm in a Δn^2 direction, and preferably controlled to 0.5 to 100 μm. When the length in the Δn^2 direction of the minute domains is too short a compared with wavelengths, scattering may not fully provided. On the other hand, when the length in the Δn^2 direction of the minute domains is too long, there is a possibility that a problem of decrease in film strength or of liquid crystalline material forming minute domains not fully oriented in the minute domains may arise.

[0032]

In the above-mentioned optical film, preferably used is the birefringent film that is a transparent film formed of solidifying a

developed layer of a liquefied solid polymer and the birefringent film is imparted the characteristic nx>ny>nz to have the transparent film, which is characterized in that nα is from 0.005 to 0.3, align a molecule in the plane of the transparent film, where (nx+ny)/2-nz=nα, a direction in which a refractive index in a film plane gives maximum is defined as X-axis, a direction perpendicular to X-axis as Y-axis, a thickness direction of the film as Z-axis, and refractive indices in each axial direction are defined as nx_1, ny_1, and nz_1, respectively.

[0033]

In the above-mentioned optical film, as the solid polymer that forms the birefringent film, at least one selected from polyamide, polyimide, polyester, polyetherketone, polyamide-imide, and polyesterimide is used.

[0034]

In the above-mentioned optical film, the birefringent film preferably satisfies the relationship Re≥10 nm, where Re=(nx-ny)d, and d is thickness.

[0035]

In the above-mentioned optical film, the birefringent film can be produced by a process comprising the steps of dissolving the solid polymer in a solvent to liquefy it, developing the liquefied polymer on a supporting substrate, drying it to form a transparent film comprising the solidified product and having the characteristic nx≈ny, and subjecting the transparent film to one or both of an

extending process and a shrinking process to align a molecule in the plane of the transparent film.

[0036]

The complex type absorbing polarizer and the birefringent film are preferably laminated and fixed with a transparent acrylic pressure-sensitive adhesive. If the complex type absorbing polarizer and the birefringent film are only layered on each other, it would be difficult to form a solid laminate with no space therebetween. Thus, they are preferably bonded together with an optically-transparent adhesive or pressure-sensitive adhesive. The pressure-sensitive adhesive is preferred in terms of convenience of bonding, and an acrylic pressure-sensitive adhesive is preferred in terms of transparency, adhesive properties, weather resistance, and heat resistance.

[0037]

In the above-mentioned optical film, with regard to the complex type absorbing polarizer, a transmittance to a linearly polarized light in a transmission direction is 80% or more, a haze value is 5% or less, and a haze value to a linearly polarized light in an absorption direction is 30% or more.

[0038]

A complex type absorbing polarizer of this invention having the above-mentioned transmittance and haze value has a high transmittance and excellent visibility for linearly polarized light in a transmission direction, and has strong optical diffusibility for

linearly polarized light in an absorption direction. Therefore, without sacrificing other optical properties and using a simple method, it may demonstrate a high transmittance and a high polarization degree, and may control unevenness of the transmittance in the case of black viewing.

[0039]

As a complex type absorbing polarizer of this invention, a polarizer is preferable that has as high as possible transmittance to linearly polarized light in a transmission direction, that is, linearly polarized light in a direction perpendicular to a direction of maximal absorption of the above-mentioned iodine based light absorbing material, and that has 80% or more of light transmittance when an optical intensity of incident linearly polarized light is set to 100. The light transmittance is preferably 85% or more, and still preferably 88% or more. Here, a light transmittance is equivalent to a value Y calculated from a spectral transmittance in 380 nm to 780 nm measured using a spectrophotometer with an integrating sphere based on CIE 1931 XYZ standard colorimetric system. In addition, since about 8% to 10% is reflected by an air interface on a front surface and rear surface of a polarizer, an ideal limit is a value in which a part for this surface reflection is deducted from 100%.

[0040]

It is desirable that a complex type absorbing polarizer does not scatter linearly polarized light in a transmission direction in

the view point of obtaining clear visibility of a display image. Accordingly, the polarizer preferably has 5% or less of haze value to the linearly polarized light in the transmission direction, more preferably 3% or less. On the other hand, in the view point of covering unevenness by a local transmittance variation by scattering, a polarizer desirably scatters strongly linearly polarized light in a absorption direction, that is, linearly polarized light in a direction for a maximal absorption of the above-mentioned iodine based light absorbing material. Accordingly, a haze value to the linearly polarized light in the absorption direction is preferably 30% or more, more preferably 40% or more, and still more preferably 50% or more. In addition, the haze value here is measured based on JIS K 7136 (how to obtain a haze of plastics-transparent material).

[0041]

The above-mentioned optical properties are obtained by compounding a function of scattering anisotropy with a function of an absorption dichroism of the polarizer. As is indicated in U.S. Pat. No. 2123902 specification, Japanese Patent Laid-Open No.9-274108, and Japanese Patent Laid-Open No.9-297204, same characteristics may probably be attained also in a way that a scattering anisotropic film having a function to selectively scatter only linearly polarized light, and a dichroism absorption type polarizer are superimposed in an axial arrangement so that an axis providing a greatest scattering and an axis providing a

greatest absorption may be parallel to each other. These methods, however, require necessity for separate formation of a scattering anisotropic film, have a problem of precision in axial joint in case of superposition, and furthermore, a simple superposition method does not provide increase in effect of the above-mentioned optical path length of the polarized light absorbed as is expected, and as a result, the method cannot easily attain a high transmission and a high polarization degree.

[0042]

This invention also relates to an optical film comprising the above-mentioned optical film and at least one of another optical film.

[0043]

This invention further relates to an image display comprising the above-mentioned optical film.

[0044]

The optical film of the present is suitable for a transmissive liquid crystal display, comprising: a liquid crystal cell comprising a pair of substrates and a liquid crystal layer sandwiched between the substrates; and a pair of polarizing plates placed on both sides of the liquid crystal cell, and the optical film is preferably placed such that the birefringent film side of the optical film faces the liquid crystal cell, as at least one of the polarizing plates. The liquid crystal cell is preferably in a VA mode.

Brief Description of Drawing

[0045]

Fig. 1 is a schematic diagram showing an example of the polarizer according to the invention; and

Fig. 2 is a graph showing the polarized absorption spectra of the polarizers in Example 1 and Comparative Example 1.

Best Mode for Carrying Out the Invention

[0047]

The optical film of the invention includes: a complex type scattering-dichroic absorbing polarizer; and a birefringent film satisfying the characteristic nx>ny>nz are laminated.

[0048]

A complex type scattering-dichroic absorbing polarizer of this invention will, hereinafter, be described referring to drawings. Fig. 1 is a conceptual view of a complex type absorbing polarizer of this invention, and the polarizer has a structure where a film is formed with an optically-transparent water-soluble resin 1 including an iodine based light absorbing material 2, and minute domains 3 are dispersed in the film concerned as a matrix. As described above, the complex type absorbing polarizer according to the invention includes the iodine based light-absorbing material 2 preferentially in the optically-transparent thermoplastic resin 1, which forms the film serving as a matrix. However, the iodine

based light-absorbing material 2 may also be allowed to exist in the minute domains 3 as long as it will have no optical effect.

[0049]

Fig. 1 shows an example of a case where the iodine based light absorbing material 2 is oriented in a direction of axis (Δn^1 direction) in which a refractive index difference between the minute domain 3 and the optically-transparent water-soluble resin 1 shows a maximal value. In minute domain 3, a polarized component in the Δn^1 direction is scattered. In Fig. 1, the Δn^1 direction in one direction in a film plane is an absorption axis. In the film plane, a Δn^2 direction perpendicular to the Δn^1 direction serves as a transmission axis. Another Δn^2 direction perpendicular to the Δn^1 direction is a thickness direction.

[0050]

As optically-transparent water-soluble resins 1, resins having optically- transparency in a visible light band and dispersing and absorbing the iodine based light absorbing materials may be used without particular limitation. For example, polyvinyl alcohols or derivatives thereof conventionally used for polarizers may be mentioned. As derivatives of polyvinyl alcohol, polyvinyl formals, polyvinyl acetals, etc. may be mentioned, and in addition derivatives modified with olefins, such as ethylene and propylene, and unsaturated carboxylic acids, such as acrylic acid, methacrylic acid, and crotonic acid, alkyl esters of unsaturated carboxylic acids, acrylamides etc. may be

mentioned. Besides, as optically-transparent water-soluble resin 1, for example, polyvinyl pyrrolidone based resins, amylose based resins, etc. may be mentioned. The above-mentioned optically-transparent water-soluble resin may be of resins having isotropy not easily generating orientation birefringence caused by molding deformation etc., and of resins having anisotropy easily generating orientation birefringence.

[0051]

Examples of the optically-transparent resin 1 also include polyester resins such as polyethylene terephthalate and polyethylene naphthalate; styrene resins such as polystyrene and acrylonitrile-styrene copolymers (AS resins); and olefin resins such as polyethylene, polypropylene, cyclo type- or norbornene structure-containing polyolefins, and olefin based resins such as ethylene-propylene copolymers. Examples thereof also include vinyl chloride resins, cellulose resins, acrylic resins, amide resins, imide resins, sulfone polymers, polyethersulfone resins, polyetheretherketone resin polymers, polyphenylene sulfide resins, vinylidene chloride resins, vinyl butyral resins, arylate resins, polyoxymethylene resins, silicone resins, and urethane resins. One or more of these resins may be used either individually or in any combination. Any cured material of a thermosetting or ultraviolet-curable type resins such as a phenol based, melamine based, acrylic based, urethane, acrylic-urethane based, epoxy based, or silicone based resin may also be used.

[0052]

In materials forming minute domains 3, it is not limited whether the material has birefringence or isotropy, but materials having birefringence is particularly preferable. Moreover, as materials having birefringence, materials (henceforth, referred to as liquid crystalline material) showing liquid crystallinity at least at the time of orientation treatment may preferably used. That is, the liquid crystalline material may show or may lose liquid crystallinity in the formed minute domain 3, as long as it shows liquid crystallinity at the orientation treatment time.

[0053]

As materials forming minute domains 3, materials having birefringences (liquid crystalline materials) may be any of materials showing nematic liquid crystallinity, smectic liquid crystallinity, and cholesteric liquid crystallinity, or of materials showing lyotropic liquid crystallinity. Moreover, materials having birefringence may be of liquid crystalline thermoplastic resins, and may be formed by polymerization of liquid crystalline monomers. When the liquid crystalline material is of liquid crystalline thermoplastic resins, in the view point of heat-resistance of structures finally obtained, resins with high glass transition temperatures may be preferable. Furthermore, it is preferable to use materials showing glass state at least at room temperatures. Usually, a liquid crystalline thermoplastic resin is oriented by heating, subsequently cooled to be fixed, and forms

minute domains 3 while liquid crystallinity are maintained. Although liquid crystalline monomers after orienting can form minute domains 3 in the state of fixed by polymerization, cross-linking, etc., some of the formed minute domains 3 may lose liquid crystallinity.

[0054]

As the above-mentioned liquid crystalline thermoplastic resins, polymers having various skeletons of principal chain types, side chain types, or compounded types thereof may be used without particular limitation. As principal chain type liquid crystal polymers, polymers, such as condensed polymers having structures where mesogen groups including aromatic units etc. are combined, for example, polyester based, polyamide based, polycarbonate based, and polyester imide based polymers, may be mentioned. As the above-mentioned aromatic units used as mesogen groups, phenyl based, biphenyl based, and naphthalene based units may be mentioned, and the aromatic units may have substituents, such as cyano groups, alkyl groups, alkoxy groups, and halogen groups.

[0055]

As side chain type liquid crystal polymers, polymers having principal chain of, such as polyacrylate based, polymethacrylate based, poly-alpha-halo acrylate based, poly-alpha-halo cyano acrylate based, polyacrylamide based, polysiloxane based, and poly malonate based principal chain as a skeleton, and having

mesogen groups including cyclic units etc. in side chains may be mentioned. As the above-mentioned cyclic units used as mesogen groups, biphenyl based, phenyl benzoate based, phenylcyclohexane based, azoxybenzene based, azomethine based, azobenzene based, phenyl pyrimidine based, diphenyl acetylene based, diphenyl benzoate based, bicyclo hexane based, cyclohexylbenzene based, terphenyl based units, etc. may be mentioned. Terminal groups of these cyclic units may have substituents, such as cyano group, alkyl group, alkenyl group, alkoxy group, halogen group, haloalkyl group, haloalkoxy group, and haloalkenyl group. Groups having halogen groups may be used for phenyl groups of mesogen groups.

[0056]

Besides, any mesogen groups of the liquid crystal polymer may be bonded via a spacer part giving flexibility. As spacer parts, polymethylene chain, polyoxymethylene chain, etc. may be mentioned. A number of repetitions of structural units forming the spacer parts is suitably determined by chemical structure of mesogen parts, and the number of repeating units of polymethylene chain is 0 to 20, preferably 2 to 12, and the number of repeating units of polyoxymethylene chain is 0 to 10, and preferably 1 to 3.

[0057]

The above-mentioned liquid crystalline thermoplastic resins preferably have glass transition temperatures of 50°C or

more, and more preferably 80°C or more. Furthermore they have approximately 2,000 to 100,000 of weight average molecular weight.

[0058]

As liquid crystalline monomers, monomers having polymerizable functional groups, such as acryloyl groups and methacryloyl groups, at terminal groups, and further having mesogen groups and spacer parts including the above-mentioned cyclic units etc. may be mentioned. Crossed-linked structures may be introduced using polymerizable functional groups having two or more acryloyl groups, methacryloyl groups, etc., and durability may also be improved.

[0059]

Materials forming minute domains 3 are not entirely limited to the above-mentioned liquid crystalline materials, and non-liquid crystalline resins may be used if they are different materials from the matrix materials. As the above-mentioned resins, polyvinyl alcohols and derivatives thereof, polyolefins, polyallylates, polymethacrylates, polyacrylamides, polyethylene terephthalates, acrylic styrene copolymers, etc. may be mentioned. Moreover, particles without birefringence may be used as materials for forming the minute domains 3. As fine-particles concerned, resins, such as polyacrylates and acrylic styrene copolymers, may be mentioned. A size of the fine-particles is not especially limited, and particle diameters of 0.05

to 500 μm may be used, and preferably 0.5 to 100 μm. Although it is preferable that materials for forming minute domains 3 is of the above-mentioned liquid crystalline materials, non-liquid crystalline materials may be mixed and used to the above-mentioned liquid crystalline materials. Furthermore, as materials for forming minute domains 3, non-liquid crystalline materials may also be independently used.

[0060]

Iodine based light absorbing material means chemical species comprising iodine and absorbs visible light, and it is thought that, in general, they are formed by interaction between optically-transparent water-soluble resins (particularly polyvinyl alcohol based resins) and poly iodine ions (I_3^-, I_5^-, etc.). An iodine based light absorbing material is also called an iodine complex. It is thought that poly iodine ions are generated from iodine and iodide ions.

[0061]

Iodine based light absorbing materials having an absorption band at least in a wavelength range of 400 to 700nm is preferably used.

[0062]

Examples of the absorbing dichroic material for use as an alternative to the iodine based light absorbing material include absorbing dichroic dyes, absorbing dichroic pigments and the like. In the invention, iodine based light-absorbing materials are

preferably used as the absorbing dichroic material. In the case where the optically-transparent resin 1 used as the matrix material is a water-soluble resin such as polyvinyl alcohol, iodine based light-absorbing materials are particularly preferred in terms of high degree of polarization and high transmittance.

[0063]

Preferably used are absorbing dichroic dyes that have heat resistance and do not lose their dichroism by decomposition or degradation even when the birefringent liquid-crystalline material is aligned by heating. As described above, the absorbing dichroic dye preferably has at least one absorption band with a dichroic ratio of at least 3 in the visible wavelength range. In the evaluation of the dichroic ratio, for example, an appropriate liquid crystal material containing a dissolved dye is used to form a homogeneously aligned liquid crystal cell, and the cell is measured for a polarized absorption spectrum, in which the absorption dichroic ratio at the absorption maximum wavelength is used as an index for evaluating the dichroic ratio. In this evaluation method, E-7 manufactured by Merck & Co. may be used as a standard liquid crystal. In this case, the dye to be used should generally have a dichroic ratio of at least about 3, preferably of at least about 6, more preferably of at least about 9, at the absorption wavelength.

[0064]

Examples of the dye having such a high dichroic ratio include azo dyes, perylene dyes and anthraquinone dyes, which are

preferably used for dye polarizers. Any of these dyes may be used in the form of a mixed dye. For example, these dyes are described in detail in JP-A No. 54-76171.

[0065]

In the case where a color polarizer is produced, a dye having an absorption wavelength appropriate to the properties of the polarizer may be used. In the case where a neutral gray polarizer is produced, two or more types of dyes may be appropriately mixed such that absorption can occur over the whole visible light range.

[0066]

In a complex type scattering-dichroic absorbing polarizer of this invention, while producing a film in which a matrix is formed with an optically-transparent water-soluble resin 1 including an iodine based light absorbing material 2, minute domains 3 (for example, an oriented birefringent material formed with liquid crystalline materials) are dispersed in the matrix concerned. Moreover, the above-mentioned refractive index difference (Δn^1) in a Δn^1 direction and a refractive index difference (Δn^2) in a Δn^2 direction are controlled to be in the above-mentioned range in the film.

[0067]

Manufacturing process of a complex type absorbing polarizer of this invention is not especially limited, and for example, the polarizer of this invention may be obtained using following production processes:

(1) a process for manufacturing a mixed solution in which a material for forming minute domains is dispersed in an optically-transparent water-soluble resin forming a matrix (description is, hereinafter, to be provided, with reference to an example of representation, for a case where a liquid crystalline material is used as a material forming the minute domains. A case by a liquid crystalline material will apply to a case by other materials.);
(2) a process in which a film is formed with the mixed solution of the above-mentioned (1);
(3) a process in which the film obtained in the above-mentioned (2) is oriented (stretched); and
(4) a process in which an iodine based light absorbing material is dispersed (dyed) in the optically-transparent water-soluble resin forming the above-mentioned matrix.
In addition, an order of the processes (1) to (4) may suitably be determined.

[0068]

In the above-mentioned process (1), a mixed solution is firstly prepared in which a liquid crystalline material forming minute domains is dispersed in an optically-transparent water-soluble resin forming a matrix. A method for preparing the mixed solution concerned is not especially limited, and a method may be mentioned of utilizing a phase separation phenomenon between the above-mentioned matrix component (an optically-transparent water-soluble resin) and a liquid crystalline material. For

example, a method may be mentioned in which a material having poor compatibility between the matrix component as a liquid crystalline material is selected, a solution of the material forming the liquid crystalline material is dispersed using dispersing agents, such as a surface active agent, in a water solution of the matrix component. In preparation of the above-mentioned mixed solution, some of combinations of the optically-transparent material forming the matrix, and the liquid crystal material forming minute domains do not require a dispersing agent. An amount used of the liquid crystalline material dispersed in the matrix is not especially limited, and a liquid crystalline material is 0.01 to 100 parts by weight to an optically-transparent water-soluble resin 100 parts by weight, and preferably it is 0.1 to 10 parts by weight. The liquid crystalline material is used in a state dissolved or not dissolved in a solvent. Examples of solvents, for example, include: water, toluene, xylene, hexane cyclohexane, dichloromethane, trichloromethane, dichloroethane, trichloroethane, tetrachloroethane, trichloroethylene, methyl ethyl ketone, methylisobutylketone, cyclohexanone, cyclopentanone, tetrahydrofuran, ethyl acetate, etc. Solvents for the matrix components and solvents for the liquid crystalline materials may be of same, or may be of different solvents.

[0069]

In the above-mentioned process (2), in order to reduce foaming in a drying process after a film formation, it is desirable

that solvents for dissolving the liquid crystalline material forming minute domains is not used in preparation of the mixed solution in the process (1). When solvents are not used, for example, a method may be mentioned in which a liquid crystalline material is directly added to an aqueous solution of an optically-transparency material forming a matrix, and then is heated above a liquid crystal temperature range in order to disperse the liquid crystalline material uniformly in a smaller state.

[0070]

In addition, a solution of a matrix component, a solution of a liquid crystalline material, or a mixed solution may include various kinds of additives, such as dispersing agents, surface active agents, ultraviolet absorption agents, flame retardants, antioxidants, plasticizers, mold lubricants, other lubricants, and colorants in a range not disturbing an object of this invention.

[0071]

In the process (2) for obtaining a film of the above-mentioned mixed solution, the above-mentioned mixed solution is heated and dried to remove solvents, and thus a film with minute domains dispersed in the matrix is produced. As methods for formation of the film, various kinds of methods, such as casting methods, extrusion methods, injection molding methods, roll molding methods, and flow casting molding methods, may be adopted. In film molding, a size of minute domains in the film is controlled to be in a range of 0.05 to 500 μm in a Δn^2 direction.

Sizes and dispersibility of the minute domains may be controlled, by adjusting a viscosity of the mixed solution, selection and combination of the solvent of the mixed solution, dispersant, and thermal processes (cooling rate) of the mixed solvent and a rate of drying. For example, a mixed solution of an optically-transparent water-soluble resin that has a high viscosity and generates high shearing force and that forms a matrix, and a liquid crystalline material forming minute domains is dispersed by agitators, such as a homogeneous mixer, being heated at a temperature in no less than a range of a liquid crystal temperature, and thereby minute domains may be dispersed in a smaller state.

[0072]

The process (3) giving orientation to the above-mentioned film may be performed by stretching the film. In stretching, uniaxial stretching, biaxial stretching, diagonal stretching are exemplified, but uniaxial stretching is usually performed. Any of dries type stretching in air and wet type stretching in an aqueous system bath may be adopted as the stretching method. When adopting a wet type stretching, an aqueous system bath may include suitable additives (boron compounds, such as boric acid; iodide of alkali metal, etc.) A stretching ratio is not especially limited, and in usual a ratio of approximately 2 to 10 times is preferably adopted.

[0073]

This stretching may orient the iodine based light absorbing

material in a direction of stretching axis. Moreover, the liquid crystalline material forming a birefringent material is oriented in the stretching direction in minute domains by the above-mentioned stretching, and as a result birefringence is demonstrated.

[0074]

It is desirable the minute domains may be deformed according to stretching. When minute domains are of non-liquid crystalline materials, approximate temperatures of glass transition temperatures of the resins are desirably selected as stretching temperatures, and when the minute domains are of liquid crystalline materials, temperatures making the liquid crystalline materials exist in a liquid crystal state such as nematic phase or smectic phase or an isotropic phase state, are desirably selected as stretching temperatures. When inadequate orientation is given by stretching process, processes, such as heating orientation treatment, may separately be added.

[0075]

In addition to the above-mentioned stretching, function of external fields, such as electric field and magnetic field, may be used for orientation of the liquid crystalline material. Moreover, liquid crystalline materials mixed with light reactive substances, such as azobenzene, and liquid crystalline materials having light reactive groups, such as a cinnamoyl group, introduced thereto are used, and thereby these materials may be oriented by

orientation processing with light irradiation etc. Furthermore, a stretching processing and the above-mentioned orientation processing may also be used in combination. When the liquid crystalline material is of liquid crystalline thermoplastic resins, it is oriented at the time of stretching, cooled at room temperatures, and thereby orientation is fixed and stabilized. Since target optical property will be demonstrated if orientation is carried out, the liquid crystalline monomer may not necessarily be in a cured state. However, in liquid crystalline monomers having low isotropic transition temperatures, a few temperature rise provides an isotropic state. In such a case, since anisotropic scattering may not be demonstrated but conversely polarized light performance deteriorates, the liquid crystalline monomers are preferably cured. Besides, many of liquid crystalline monomers will be crystallized when left at room temperatures, and then they will demonstrate anisotropic scattering and polarized light performance conversely deteriorate, the liquid crystalline monomers are preferably cured. In the view point of these phenomena, in order to make orientation state stably exist under any kind of conditions, liquid crystalline monomers are preferably cured. In curing of a liquid crystalline monomer, for example, after the liquid crystalline monomer is mixed with photopolymerization initiators, dispersed in a solution of a matrix component and oriented, in either of timing (before dyed or after dyed by iodine based light absorbing materials), the liquid

crystalline monomer is cured by exposure with ultraviolet radiation etc. to stabilize orientation. Desirably, the liquid crystalline monomer is cured before dyed with iodine based light absorbing materials.

[0076]

As a process (4) in which the iodine based light absorbing material is dispersed in the optically-transparent water-soluble resin used for forming the above-mentioned matrix, in general, a method in which the above-mentioned film is immersed into a bath of aqueous system including iodine dissolved with auxiliary agents of iodide of alkali metals, such as potassium iodide may be mentioned. As mentioned above, an iodine based light absorbing material is formed by interaction between iodine dispersed in the matrix and the matrix resin. Timing of immersing may be before or after the above-mentioned stretching process (3). The iodine based light absorbing material is, in general, remarkably formed by being passed through a stretching process. A concentration of the aqueous system bath including iodine, and a percentage of the auxiliary agents, such as iodide of alkali metals may not especially be limited, but general iodine dyeing techniques may be adopted, and the above-mentioned concentration etc. may arbitrarily be changed.

[0077]

Moreover, a percentage of the iodine in the polarizer obtained is not especially limited, but a percentage of the

optically-transparent water-soluble resin and the iodine are preferably controlled so that the iodine is 0.05 to 50 parts by weight grade to the optically-transparent water-soluble resin 100 parts by weight, and more preferably 0.1 to 10 parts by weight.

[0078]

In a case the absorbing dichroic dye is used as the absorbing dichroic material, a percentage of the absorbing dichroic dye in the polarizer obtained is not especially limited, but a percentage of the optically-transparent thermoplastic resin and the absorbing dichroic dye is preferably so that the absorbing dichroic dye is controlled to be 0.01 to 100 parts by weight grade to the optically-transparent thermoplastic resin 100 parts by weight, and more preferably 0.05 to 50 parts by weight.

[0079]

In production of the complex type absorbing polarizer, processes for various purposes (5) may be given other than the above-mentioned processes (1) to (4). As a process (5), for example, a process in which a film is immersed in water bath and swollen may be mentioned for the purpose of mainly improving iodine dyeing efficiency of the film. Besides, a process in which a film is immersed in a water bath including arbitrary additives dissolved therein may be mentioned. A process in which a film is immersed in an aqueous solution including additives, such as boric acid and borax, for the purpose of cross-linking a water-soluble resin (matrix) may be mentioned. Moreover, for the

purpose of mainly adjusting an amount balance of the dispersed iodine based light absorbing materials, and adjusting a hue, a process in which a film is immersed to an aqueous solution including additives, such as an iodide of an alkaline metals may be mentioned.

[0080]

As for the process (3) of orienting (stretching) of the above-mentioned film, the process (4) of dispersing and dyeing the iodine based light absorbing material to a matrix resin and the above-mentioned process (5), so long as each of the processes (3) and (4) is provided at least 1 time, respectively, a number, order and conditions (a bath temperature, immersion period of time, etc.) of the processes, may arbitrarily be selected, each process may separately be performed and furthermore a plurality of processes may simultaneously be performed. For example, a cross-linking process of the process (5) and the stretching process (3) may be carried out simultaneously.

[0081]

In addition, although the iodine based light absorbing material used for dyeing, boric acid used for cross-linking are permeated into a film by immersing the film in an aqueous solution as mentioned above, instead of this method, a method may be adopted that arbitrary types and amounts may be added before film formation of the process (2) and before or after preparation of a mixed solution in the process (1). And both

methods may be used in combination. However, when high temperatures (for example, no less than 80°C) is required in the process (3) at the time of stretching etc., in the view point of heat resistance of the iodine based light absorbing material, the process (4) for dispersing and dyeing the iodine based light absorbing material may be desirably performed after the process (3).

[0082]

A film given the above treatments is desirably dried using suitable conditions. Drying is performed according to conventional methods.

[0083]

A thickness of the obtained polarizer (film) is not especially limited, in general, but it is 1 μm to 3 mm, preferably 5 μm to 1 mm, and more preferably 10 to 500 μm.

[0084]

A polarizer obtained in this way does not especially have a relationship in size between a refractive index of the birefringent material forming minute domains and a refractive index of the matrix resin in a stretching direction, whose stretching direction is in a Δn^1 direction and two directions perpendicular to a stretching axis are Δn^2 directions. Moreover, the stretching direction of an iodine based light absorbing material is in a direction demonstrating maximal absorption, and thus a polarizer having a maximally demonstrated effect of absorption and

scattering may be realized.

[0085]

The above-described polarizer may be used as a polarizing plate with a transparent protective layer prepared at least on one side thereof using a usual method. The transparent protective layer may be prepared as an application layer by polymers, or a laminated layer of films. Proper transparent materials may be used as a transparent polymer or a film material that forms the transparent protective layer, and the material having outstanding transparency, mechanical strength, heat stability and outstanding moisture interception property, etc. may be preferably used. As materials of the above-mentioned protective layer, for example, polyester type polymers, such as polyethylene terephthalate and polyethylenenaphthalate; cellulose type polymers, such as diacetyl cellulose and triacetyl cellulose; acrylics type polymer, such as poly methylmethacrylate; styrene type polymers, such as polystyrene and acrylonitrile-styrene copolymer (AS resin); polycarbonate type polymer may be mentioned. Besides, as examples of the polymer forming a protective film, polyolefin type polymers, such as polyethylene, polypropylene, polyolefin that has cyclo- type or norbornene structure, ethylene-propylene copolymer; vinyl chloride type polymer; amide type polymers, such as nylon and aromatic polyamide; imide type polymers; sulfone type polymers; polyether sulfone type polymers; polyether-ether ketone type polymers; poly phenylene sulfide type

polymers; vinyl alcohol type polymer; vinylidene chloride type polymers; vinyl butyral type polymers; arylate type polymers; polyoxymethylene type polymers; epoxy type polymers; or blend polymers of the above-mentioned polymers may be mentioned. Films made of heat curing type or ultraviolet ray curing type resins, such as acryl based, urethane based, acryl urethane based, epoxy based, and silicone based, etc. may be mentioned.

[0086]

Moreover, as is described in Japanese Patent Laid-Open Publication No. 2001-343529 (WO 01/37007), polymer films, for example, resin compositions including (A) thermoplastic resins having substituted and/or non-substituted imido group is in side chain, and (B) thermoplastic resins having substituted and/or non-substituted phenyl and nitrile group in sidechain may be mentioned. As an illustrative example, a film may be mentioned that is made of a resin composition including alternating copolymer comprising iso-butylene and N-methyl maleimide, and acrylonitrile-styrene copolymer. A film comprising mixture extruded article of resin compositions etc. may be used.

[0087]

As a transparent protection film, if polarization property and durability are taken into consideration, cellulose based polymer, such as triacetyl cellulose, is preferable, and especially triacetyl cellulose film is suitable. In general, a thickness of a transparent protection film is 500 μm or less, preferably 1 to 300 μm, and

especially preferably 5 to 300 μm. In addition, when transparent protection films are provided on both sides of the polarizer, transparent protection films comprising same polymer material may be used on both of a front side and a back side, and transparent protection films comprising different polymer materials etc. may be used.

[0088]

Moreover, it is preferable that the protection film may have as little coloring as possible. Accordingly, a protection film having a retardation value in a film thickness direction represented by $Rth=[(nx+ny)/2 - nz] \times d$ of -90 nm to +75 nm (where, nx and ny represent principal indices of refraction in a film plane, nz represents refractive index in a film thickness direction, and d represents a film thickness) may be preferably used. Thus, coloring (optical coloring) of polarizing plate resulting from a protection film may mostly be cancelled using a protection film having a retardation value (Rth) of -90 nm to +75 nm in a thickness direction. The retardation value (Rth) in a thickness direction is preferably -80 nm to +60 nm, and especially preferably -70 nm to +45 nm.

[0089]

A hard coat layer may be prepared, or antireflection processing, processing aiming at sticking prevention, diffusion or anti glare may be performed onto the face on which the polarizer of the above described transparent protective film has not been adhered.

[0090]

A hard coat processing is applied for the purpose of protecting the surface of the polarizing plate from damage, and this hard coat film may be formed by a method in which, for example, a curable coated film with excellent hardness, slide property etc. is added on the surface of the protective film using suitable ultraviolet curable type resins, such as acrylic type and silicone type resins. Antireflection processing is applied for the purpose of antireflection of outdoor daylight on the surface of a polarizing plate and it may be prepared by forming an antireflection film according to the conventional method etc. Besides, a sticking prevention processing is applied for the purpose of adherence prevention with adjoining layer.

[0091]

In addition, an anti glare processing is applied in order to prevent a disadvantage that outdoor daylight reflects on the surface of a polarizing plate to disturb visual recognition of transmitting light through the polarizing plate, and the processing may be applied, for example, by giving a fine concavo-convex structure to a surface of the protective film using, for example, a suitable method, such as rough surfacing treatment method by sandblasting or embossing and a method of combining transparent fine particle. As a fine particle combined in order to form a fine concavo-convex structure on the above-mentioned surface, transparent fine particles whose average particle size is

0.5 to 50 μm, for example, such as inorganic type fine particles that may have conductivity comprising silica, alumina, titania, zirconia, tin oxides, indium oxides, cadmium oxides, antimony oxides, etc., and organic type fine particles comprising cross-linked of non-cross-linked polymers may be used. When forming fine concavo-convex structure on the surface, the amount of fine particle used is usually about 2 to 50 weight parts to the transparent resin 100 weight parts that forms the fine concavo-convex structure on the surface, and preferably 5 to 25 weight parts. An anti glare layer may serve as a diffusion layer (viewing angle expanding function etc.) for diffusing transmitting light through the polarizing plate and expanding a viewing angle etc.

[0092]

In addition, the above-mentioned antireflection layer, sticking prevention layer, diffusion layer, anti glare layer, etc. may be built in the protective film itself, and also they may be prepared as an optical layer different from the protective layer.

[0093]

Adhesives are used for adhesion processing of the above described polarizer and the transparent protective film. As adhesives, isocyanate derived adhesives, polyvinyl alcohol derived adhesives, gelatin derived adhesives, vinyl polymers derived latex type, aqueous polyesters derived adhesives, etc. may be mentioned. The above-described adhesives are usually used as adhesives comprising aqueous solution, and usually contain solid of 0.5 to 60

% by weight.

[0094]

A polarizing plate of the present invention is manufactured by adhering the above described transparent protective film and the polarizer using the above described adhesives. The application of adhesives may be performed to any of the transparent protective film or the polarizer, and may be performed to both of them. After adhered, drying process is given and the adhesion layer comprising applied dry layer is formed. Adhering process of the polarizer and the transparent protective film may be performed using a roll laminator etc. Although a thickness of the adhesion layer is not especially limited, it is usually approximately 0.1 to 5 μm.

[0095]

The optical film of the invention includes the complex type absorbing polarizer (which may be used as a complex absorbing polarizing plate laminated with the protective film or the like) and a birefringent film that has the characteristic nx>ny>nz. The birefringent film may be produced by any method as long as it will satisfy the requirement nx>ny>nz.

[0096]

The birefringent film is preferably a transparent film formed of solidifying a developed layer of a liquefied solid polymer and the birefringent film is preferably imparted the characteristic nx>ny>nz to have the transparent film, which is characterized in that nα is from 0.005 to 0.3, align a molecule in the plane of the transparent

film, where (nx+ny)/2-nz=nα, a direction in which a refractive index in a film plane gives maximum is defined as X-axis, a direction perpendicular to X-axis as Y-axis, a thickness direction of the film as Z-axis, and refractive indices in each axial direction are defined as nx_1, ny_1, and nz_1, respectively. Concerning such a birefringent film, Re and Rz can be easily controlled.

[0097]

The solid polymer for forming the birefringent film may be of any type, and one or more appropriate types of optically transparent solid polymers may be used. Preferably, the polymer can form a highly transparent film with a light transmittance of at least 75%, particularly of at least 85%. In view of stable mass productivity of the transparent film with the above nα value, the solid polymer preferably exhibits negative birefringence such that the refractive index in the stretching direction is relatively low.

[0098]

Examples of the solid polymer showing the negative birefringence include polyamide, polyimide, polyester, polyetherketone, polyaryletherketone, polyamide-imide, and polyesterimide. A single type of the solid polymer or a mixture of two or more types of the solid polymers may be used to form the birefringent film. While the solid polymer may have any molecular weight, in general, the solid polymer preferably has a weight average molecular weight of 1,000 to 1,000,000, more preferably of 1,500 to 750,000, particularly preferably of 2,000 to 500,000, in view of

processability into films or the like.

[0099]

The transparent film, which forms the base of the birefringent film, may be formed by a process including the steps of liquefying the solid polymer, developing the liquefied polymer and solidifying the developed layer. Various additives such as stabilizers, plasticizers, and metals may be added as needed in the process of forming the transparent film. The process of liquefying the solid polymer may employ any appropriate method such as a method of heating and melting a thermoplastic solid polymer and a method of dissolving the solid polymer in a solvent to form a solution.

[0100]

Thus, the developed layer may be solidified by cooling the developed layer in the former case with the melt or by removing the solvent from the developed layer and drying the layer in the latter case with the solution. The drying may be performed using one or more appropriate methods such as natural seasoning (air drying), drying by heating, particularly drying by heating at a temperature of 40 to 200°C, and drying under reduced pressure. In view of production efficiency and suppression of the occurrence of optical anisotropy, a method of applying a polymer solution is preferred.

[0101]

The solvent may be one or more of appropriate solvents such as methylene chloride, cyclohexanone, trichloroethylene,

tetrachloroethane, N-methylpyrrolidone, and tetrahydrofuran. In view of suitable viscosity for the film formation, the solution preferably contains 2 to 100 parts by weight, more preferably 5 to 50 parts by weight, particularly preferably 10 to 40 parts by weight of the dissolved solid polymer, based on 100 parts by weight of the solvent.

[0102]

The liquefied solid polymer may be developed using any appropriate film-forming method such as a casting method such as spin coating, roll coating, flow coating, printing, dip coating, film casting, bar coating, and gravure coating, and an extrusion method. In view of mass productivity or the like of films with less unevenness in thickness or alignment, the film-forming solution method such as the casting method is preferably used. In this case, solvent-soluble polyimides prepared from an aromatic dianhydride and a polyaromatic diamine are preferably used (JP-A No. 08-511812).

[0103]

The characteristic that nα is from 0.005 to 0.3 can be provided in the process of solidifying the developed layer of the liquefied solid polymer to form a transparent film. In the case of the illustrated solid polymer exhibiting negative birefringence, the nα characteristic can be provided only by the process of solidifying the developed layer of the liquefied material.

[0104]

The $n\alpha \cdot d$ value of the final birefringent film product, namely Rz, depends on $n\alpha$. In view of the control of Rz, particularly in view of thin film production, the $n\alpha$ of the transparent film is preferably from 0.01 to 0.20, more preferably from 0.02 to 0.15. The above d is the thickness of the film.

[0105]

The characteristic of the birefringent film, nx>ny>nz, may be provided by subjecting the transparent film to the process of aligning the molecule in the plane of the film. Specifically, the process of developing the liquefied material to form the transparent film is for the purpose of controlling nz, and the transparent film obtained by this process generally has the characteristic nx≈ny and thus the characteristic Re≈0 nm. In such a case, even if the thickness of the film is set at 50 μm, Re should be less than 10 nm, particularly from 0 to 5 nm. Re=0 means nx=ny.

[0106]

Concerning the above-described production method, therefore, it may also be appreciated that the process of forming the transparent film serves to control nz and thus Rz, while the process of aligning the molecule in the plane of the transparent film serves to control nx and ny and thus Re. This role-sharing method has the advantages that the goal can be achieved with a stretch ratio lower than that for the conventional method, such as the biaxial stretching method, in which Rz and Re are simultaneously controlled, and that biaxial birefringent films with the Rz and Re

characteristics based on nx>ny>nz and with high accuracy in each optical axis can be easily produced.

[0107]

The process of aligning the molecule in the plane of the transparent film may be the process of extending and/or shrinking the film. For example, the extending process may be a stretching process or the like. The stretching process may be one or more of appropriate methods such as sequential or simultaneous biaxial stretching methods and free-end or fixed-end uniaxial stretching methods. In terms of suppressing the bowing phenomenon, uniaxial stretching methods are preferred. The temperature of the stretching process may be set according conventional techniques and generally set at a temperature close to or higher than the glass transition temperature of the solid polymer for forming the transparent film.

[0108]

On the other hand, the shrinking process may include the steps of forming the transparent film on a substrate by coating and applying a contractive force by utilizing changes in size associated with the substrate temperature changes and the like. In this case, a substrate with the ability to shrink, such as a heat-shrinkable film, may also be used. When such a substrate is used, a stretching machine or the like is preferably used to control the rate of shrinkage.

[0109]

The magnitude of Rz and Re of the resulting birefringent film may be controlled by the type of the solid polymer, the method of forming the developed layer, such as the liquefied material coating method, the method of solidifying the developed layer, such as drying conditions, or the thickness of the transparent film to be formed. The thickness of the transparent film is generally from 0.5 to 100 μm, preferably from 1 to 50 μm, particularly preferably from 2 to 20 μm.

[0110]

In view of practical performance such as optical compensation, the birefringent film preferably has an Re(Re/d) value (per 1 μm film thickness) of 3 to 30 nm, more preferably of 4 to 20 nm, wherein d is the thickness of the film, nx>ny (nx is with respect to the slow axis), and (nx-ny)d=Re≥10 nm. The birefringent film preferably has an Rz(Rz/d) value (per 1 μm film thickness) of at least 5 nm, more preferably of 10 to 100 nm, particularly of 20 to 70 nm.

[0111]

The method for producing the birefringent film preferably includes the steps of dissolving the solid polymer in a solvent to liquefy it, developing the liquefied polymer on a supporting substrate, drying it to form a transparent film comprising the solidified product and having the characteristic nx=ny or nx≈ny, and subjecting the transparent film to one or both of an extending process and a shrinking process to align the molecule in the plane

so that the characteristic nx>ny>nz is imparted to the film. This method can process the transparent film being supported on the substrate and has high production efficiency or high process accuracy and allows continuous production.

[0112]

Any appropriate material may be used and not limited for the supporting substrate. The supporting substrate and the transparent film may be integrated to form the birefringent film, or the transparent film may be separated from the supporting substrate to form the birefringent film. In the former case of the supporting substrate-bonded type, the retardation produced in the supporting substrate by the stretching process or the like may also be utilized for the retardation of the birefringent film. The latter separated type is advantageous when the stretching process or the like produces an adverse retardation or the like in the supporting substrate. In the former supporting substrate- integrated type, a transparent polymer substrate is preferably used as the supporting substrate. In the case of the supporting substrate- integrated type, the supporting substrate may also serve as the protective film for the polarizer.

[0113]

Examples of the material for forming the polymer substrate include those illustrated above for the solid polymer, acetate polymers, polyethersulfone, polysulfone, polycarbonate, polynorbornene, polyolefin, acrylic polymers, cellulose resins,

polyarylate, polystyrene, polyvinyl alcohol, polyvinyl chloride, polyvinylidene chloride, liquid crystal polymers, and thermosetting or ultraviolet-curable resins such as acrylic, urethane, acrylic urethane, epoxy, or silicone resins. In terms of suppressing the retardation effect of the supporting substrate, highly isotropic materials such as acetate polymers are preferred.

[0114]

While the complex type absorbing polarizer (or the complex type absorbing polarizing plate) and the birefringent film may be only stacked to form the optical film of the invention, they are preferably laminated with no air space left between them by the use of an adhesive or pressure-sensitive adhesive, in terms of workability or light use efficiency.

[0115]

In the bonding for forming the optical film, the optical axes may be arranged to make an appropriate angle depending on the desired retardation properties. The birefringent film and the polarizer may be laminated by any method such as known conventional methods using the adhesive layer, the pressure-sensitive layer or the like as described above.

[0116]

The adhesive and the pressure-sensitive adhesive are not especially limited. For example, acrylic type polymers; silicone type polymers; polyesters, polyurethanes, polyamides, polyethers; fluorine type and rubber type polymers, such as natural rubber,

synthetic rubber may be suitably selected as a base polymer. Especially, the adhesive and the pressure-sensitive may be preferably used, which is excellent in optical transparency, showing adhesion characteristics with moderate wettability, cohesiveness and adhesive property and has outstanding weather resistance, heat resistance, etc.

[0117]

The adhesive or the pressure-sensitive adhesive preferably has no absorption in the visible light range and preferably has a refractive index as close as possible to the refractive index of each layer in terms of suppressing surface reflection. In this point of view, for example, acrylic pressure-sensitive adhesives are preferably used.

[0118]

The adhesive or the pressure-sensitive adhesive may contain any crosslinking agent appropriate to the base polymer. The adhesive layer may contain additives, for example, such as natural or synthetic resins, adhesive resins, glass fibers, glass beads, metal powder, fillers comprising other inorganic powder etc., pigments, colorants and antioxidants. Moreover, it may be an adhesive layer that contains fine particle and shows optical diffusion nature.

[0119]

In addition, in the present invention, ultraviolet absorbing property may be given to the above-mentioned each layer, such as

an optical film etc. and a pressure-sensitive adhesive layer, using a method of adding UV absorbents, such as salicylic acid ester type compounds, benzophenol type compounds, benzotriazol type compounds, cyano acrylate type compounds, and nickel complex salt type compounds.

[0120]

The adhesive or the pressure-sensitive adhesive is generally used in the form of an adhesive solution with a solids content of about 10 to about 50% by weight, in which the base polymer or a composition thereof is dissolved or dispersed in a solvent. Any appropriate solvent such as water and an organic solvent such as toluene and ethyl acetate may be selected and used depending on the type of the adhesive.

[0121]

The adhesive layer and the pressure-sensitive adhesive layer may also be prepared on one side or both sides of an optical film as a layer in which pressure-sensitive adhesives with different composition or different kind etc. are laminated together. Thickness of the pressure-sensitive adhesive layer may be suitably determined depending on a purpose of usage or adhesive strength, etc., and generally is 1 to 500 μm, preferably 5 to 200 μm, and more preferably 10 to 100 μm.

[0122]

An adhesive layer and the pressure-sensitive adhesive layer may be prepared on the optical film. The pressure-sensitive

adhesive layer is used for adhesion with a liquid crystal cell, and lamination other optical layers.

[0123]

A temporary separator is attached to an exposed side of an pressure-sensitive adhesive layer to prevent contamination etc., until it is practically used. Thereby, it can be prevented that foreign matter contacts pressure-sensitive adhesive layer in usual handling. As a separator, without taking the above-mentioned thickness conditions into consideration, for example, suitable conventional sheet materials that is coated, if necessary, with release agents, such as silicone type, long chain alkyl type, fluorine type release agents, and molybdenum sulfide may be used. As a suitable sheet material, plastics films, rubber sheets, papers, cloths, no woven fabrics, nets, foamed sheets and metallic foils or laminated sheets thereof may be used.

[0124]

The optical film of the invention may be used for a liquid crystal display in a conventional manner. The liquid crystal display may include a liquid crystal cell, polarizing plates placed on both sides of the liquid crystal cell, and any of various types of optical layers and the like. The above-mentioned optical film is used on at least one side of the liquid crystal cell. The liquid crystal display may be formed in a conventional manner. Specifically, a general liquid crystal display may be formed by assembling a liquid crystal cell, optical elements, and optional components such as a lighting

system in an appropriate manner and incorporating a driving circuit and the like, while any conventional techniques may be used except that the optical film of the invention is used. The liquid crystal cell may be of any type such as TN type, STN type and π type. In particular, VA type is preferably used.

[0125]

Additionally, any other appropriate components such as a diffusing plate, an antiglare layer, an antireflection film, a protective plate, a prism array, a lens array sheet, a light diffusion plate, and a backlight may also be placed in one or more layers at appropriate positions to form a liquid crystal display.

[0126]

While the optical film may be formed by independently and sequentially laminating the components in the process of manufacturing a liquid crystal display or the like, the optical film formed by pre-lamination has the advantages that it has stable quality and good assembling workability and can improve the process of manufacturing liquid crystal displays or the like. The lamination may be performed using any appropriate adhesive means such as a pressure-sensitive adhesive layer. In the process of bonding the optical film or any other optical film, their optical axes may be arranged so as to make an appropriate angles depending on the desired retardation properties.

[0127]

An optical film of the present invention may be used in

practical use as an optical layer laminated with other optical layers. Although there is especially no limitation about the optical layers, one layer or two layers or more of optical layers, which may be used for formation of a liquid crystal display etc., such as a reflector, a transflective plate, a retardation plate (a half wavelength plate and a quarter wavelength plate included), and a viewing angle compensation film, may be used. Especially preferable polarizing plates are; a reflection type polarizing plate or a transflective type polarizing plate in which a reflector or a transflective reflector is further laminated onto a polarizing plate of the present invention; an elliptically polarizing plate or a circular polarizing plate in which a retardation plate is further laminated onto the polarizing plate; a wide viewing angle polarizing plate in which a viewing angle compensation film is further laminated onto the polarizing plate; or a polarizing plate in which a brightness enhancement film is further laminated onto the polarizing plate.

[0128]

A reflective layer is prepared on a polarizing plate to give a reflection type polarizing plate, and this type of plate is used for a liquid crystal display in which an incident light from a view side (display side) is reflected to give a display. This type of plate does not require built-in light sources, such as a backlight, but has an advantage that a liquid crystal display may easily be made thinner. A reflection type polarizing plate may be formed using suitable methods, such as a method in which a reflective layer of

metal etc. is, if required, attached to one side of a polarizing plate through a transparent protective layer etc.

[0129]

In addition, a transflective type polarizing plate may be obtained by preparing the above-mentioned reflective layer as a transflective type reflective layer, such as a half-mirror etc. that reflects and transmits light. A transflective type polarizing plate is usually prepared in the backside of a liquid crystal cell and it may form a liquid crystal display unit of a type in which a picture is displayed by an incident light reflected from a view side (display side) when used in a comparatively well-lighted atmosphere. And this unit displays a picture, in a comparatively dark atmosphere, using embedded type light sources, such as a back light built in backside of a transflective type polarizing plate. That is, the transflective type polarizing plate is useful to obtain of a liquid crystal display of the type that saves energy of light sources, such as a back light, in a well-lighted atmosphere, and can be used with a built-in light source if needed in a comparatively dark atmosphere etc.

[0130]

The above-mentioned polarizing plate may be used as elliptically polarizing plate or circularly polarizing plate on which the retardation plate is laminated. A description of the above-mentioned elliptically polarizing plate or circularly polarizing plate will be made in the following paragraph. These polarizing

plates change linearly polarized light into elliptically polarized light or circularly polarized light, elliptically polarized light or circularly polarized light into linearly polarized light or change the polarization direction of linearly polarization by a function of the retardation plate. As a retardation plate that changes circularly polarized light into linearly polarized light or linearly polarized light into circularly polarized light, what is called a quarter wavelength plate (also called $\lambda/4$ plate) is used. Usually, half-wavelength plate (also called $\lambda/2$ plate) is used, when changing the polarization direction of linearly polarized light.

[0131]

Elliptically polarizing plate is effectively used to give a monochrome display without above-mentioned coloring by compensating (preventing) coloring (blue or yellow color) produced by birefringence of a liquid crystal layer of a super twisted nematic (STN) type liquid crystal display. Furthermore, a polarizing plate in which three-dimensional refractive index is controlled may also preferably compensate (prevent) coloring produced when a screen of a liquid crystal display is viewed from an oblique direction. Circularly polarizing plate is effectively used, for example, when adjusting a color tone of a picture of a reflection type liquid crystal display that provides a colored picture, and it also has function of antireflection. For example, a retardation plate may be used that compensates coloring and viewing angle, etc. caused by birefringence of various wavelength

plates or liquid crystal layers etc. Besides, optical characteristics, such as retardation, may be controlled using laminated layer with two or more sorts of retardation plates having suitable retardation value according to each purpose. As retardation plates, birefringence films formed by stretching films comprising suitable polymers, such as polycarbonates, norbornene type resins, polyvinyl alcohols, polystyrenes, poly methyl methacrylates, polypropylene; polyallylates and polyamides; oriented films comprising liquid crystal materials, such as liquid crystal polymer; and films on which an alignment layer of a liquid crystal material is supported may be mentioned. A retardation plate may be a retardation plate that has a proper retardation according to the purposes of use, such as various kinds of wavelength plates and plates aiming at compensation of coloring by birefringence of a liquid crystal layer and of visual angle, etc., and may be a retardation plate in which two or more sorts of retardation plates is laminated so that optical properties, such as retardation, may be controlled.

[0132]

The polarizing plate with which a polarizing plate and a brightness enhancement film are adhered together is usually used being prepared in a backside of a liquid crystal cell. A brightness enhancement film shows a characteristic that reflects linearly polarized light with a predetermined polarization axis, or circularly polarized light with a predetermined direction, and that

transmits other light, when natural light by back lights of a liquid crystal display or by reflection from a back-side etc., comes in. The polarizing plate, which is obtained by laminating a brightness enhancement film to a polarizing plate, thus does not transmit light without the predetermined polarization state and reflects it, while obtaining transmitted light with the predetermined polarization state by accepting a light from light sources, such as a backlight. This polarizing plate makes the light reflected by the brightness enhancement film further reversed through the reflective layer prepared in the backside and forces the light re-enter into the brightness enhancement film, and increases the quantity of the transmitted light through the brightness enhancement film by transmitting a part or all of the light as light with the predetermined polarization state. The polarizing plate simultaneously supplies polarized light that is difficult to be absorbed in a polarizer, and increases the quantity of the light usable for a liquid crystal picture display etc., and as a result luminosity may be improved.

[0133]

The suitable films are used as the above-mentioned brightness enhancement film. Namely, multilayer thin film of a dielectric substance; a laminated film that has the characteristics of transmitting a linearly polarized light with a predetermined polarizing axis, and of reflecting other light, such as the multilayer laminated film of the thin film having a different

refractive-index anisotropy; an aligned film of cholesteric liquid-crystal polymer; a film that has the characteristics of reflecting a circularly polarized light with either left-handed or right-handed rotation and transmitting other light, such as a film on which the aligned cholesteric liquid crystal layer is supported; etc. may be mentioned.

[0134]

Subsequently, organic electro luminescence equipment (organic EL display) will be explained. Generally, in organic EL display, a transparent electrode, an organic luminescence layer and a metal electrode are laminated on a transparent substrate in an order configuring an illuminant (organic electro luminescence illuminant). Here, an organic luminescence layer is a laminated material of various organic thin films, and much compositions with various combination are known, for example, a laminated material of hole injection layer comprising triphenylamine derivatives etc., a luminescence layer comprising fluorescent organic solids, such as anthracene; a laminated material of electronic injection layer comprising such a luminescence layer and perylene derivatives, etc.; laminated material of these hole injection layers, luminescence layer, and electronic injection layer etc.

[0135]

In an organic EL display containing an organic electro luminescence illuminant equipped with a transparent electrode on

a surface side of an organic luminescence layer that emits light by impression of voltage, and at the same time equipped with a metal electrode on a back side of organic luminescence layer, a retardation plate may be installed between these transparent electrodes and a polarizing plate, while preparing the polarizing plate on the surface side of the transparent electrode.

[0136]

Since the retardation plate and the polarizing plate have function polarizing the light that has entered as incident light from outside and has been reflected by the metal electrode, they have an effect of making the mirror surface of metal electrode not visible from outside by the polarization action. If a retardation plate is configured with a quarter wavelength plate and the angle between the two polarization directions of the polarizing plate and the retardation plate is adjusted to $\pi/4$, the mirror surface of the metal electrode may be completely covered.

Examples

[0137]

Examples of this invention will, hereinafter, be shown, and specific descriptions will be provided. In addition, "parts" in following sections represents parts by weight.

[0138]

Refractive indices nx, ny and nz at 550 nm were measured with an automatic birefringence-measuring system (Automatic

Birefringence Analyzer KOBRA 21ADH manufactured by Oji Scientific Instruments), and nα, in-plane retardation Re, and thickness-direction retardation Rth were calculated.

[0139]

<Preparation of Complex Type Scattering-Dichroic Absorbing Polarizing Plate >

(Complex Type Scattering-Dichroic Absorbing Polarizer)

A polyvinyl alcohol aqueous solution with a solid matter content of 13 weight % in which a polyvinyl alcohol resin with a polymerization degree of 2400 and a saponification degree of 98.5 %, a liquid crystalline monomer (a nematic liquid crystal temperature is in the range of from 40 to 70°) having an acryloyl group at each of both terminals of a mesogen group and glycerin were mixed together so that a ratio of polyvinyl alcohol: a liquid crystalline monomer: glycerin = 100: 5: 15 (in weight ratio) and the mixture was heated to a temperature equal to or higher than a liquid crystal temperature range and agitated with a homomixer to thereby obtain a mixed solution. Bubbles existing in the mixed solution were defoamed by leaving the solution at room temperature (23°c) as it was, thereafter, the solution is coated by means of a casting method, subsequently thereto, and the wet coat was dried and to thereafter obtains a whitened mixed film with a thickness of 70 μm. The mixed film was heat-treated at 130°C for 10 min.

[0140]

The mixed film was immersed in a water bath at 30°C and

swollen, thereafter, the swollen film was stretched about three times while being immersed in an aqueous solution of iodine and potassium iodide in a ratio of 1 to 7 in weight (a dyeing bath, with a concentration of 0.32 weight %) at 30°C, thereafter the stretched film was further stretched to a total stretch magnification of being about six times while being immersed in a 3 weight % boric acid aqueous solution (crosslinking bath) at 50°C, followed by immersing further the stretched film in 4 weight % boric acid aqueous solution (crosslinking bath) at 50°C. Then, hue adjustment was conducted by immersing the film in 5 weight % potassium iodide aqueous solution bath at 30°C. Subsequent thereto, the film was dried at 50°C for 4 minutes to obtain a polarizer of the present invention.

[0141]

(Confirmation of Generation of Anisotropic Scattering and Measurement of Refractive Index)

The obtained polarizer was observed under a polarization microscope and it was able to be confirmed that numberless dispersed minute domains of a liquid crystalline monomer were formed in a polyvinyl alcohol matrix. The liquid crystalline monomer is oriented in a stretching direction and an average size of minute domains in the stretching direction (Δn^1 direction) was in the range of from 5 to 10 μm. And an average size of minute domains in a direction perpendicular to the stretching direction (Δn^2 direction) was in the range of from 0.5 to 3 μm.

[0142]

Refractive indices of the matrix and the minute domain were separately measured. Measurement was conducted at 20°C. A refractive index of a stretched film constituted only of a polyvinyl alcohol film stretched in the same conditions as the wet stretching was measured with an Abbe's refractometer (measurement light wavelength with 589 nm) to obtain a refractive index in the stretching direction (Δn^1 direction) = 1.54 and a refractive index in Δn^2 direction = 1.52. Refractive indexes (n_e: an extraordinary light refractive index and n_0: an ordinary light refractive index) of a liquid crystalline monomer were measured. An ordinary light refractive index n_0 was measured of the liquid crystalline monomer orientation-coated on a high refractive index glass which is vertical alignment-treated with an Abbe's refractometer (measurement light with 589 nm). On the other hand, the liquid crystalline monomer is injected into a liquid crystal cell which is homogenous alignment-treated and a retardation (Δn x d) was measured with an automatic birefringence measurement instrument (automatic birefringence meter KOBRA21ADH) manufactured by Ohoji Keisokuki K.K.) and a cell gap (d) was measured separately with an optical interference method to calculate Δn from retardation/cell gap and to obtain the sum of Δn and n_0 as n_e. An extraordinary light refractive index n_e (corresponding to a refractive index in the Δn^1 direction) = 1.64 and n_0 (corresponding to a refractive index of Δn^2 direction) = 1.52. Therefore, calculation was resulted in $\Delta n^1 = 1.64 - 1.52 = 0.10$ and $\Delta n^2 = 1.52 - 1.52 = 0.00$. It was confirmed from the measurement

described above that a desired anisotropic scattering was able to occur.

[0143]

<Birefringent Film (1)>

A cyclohexanone solution of 15% by weight of a polyimide synthesized from 2,2'-bis(3,4-dicarboxyphenyl)hexafluoropropane and 2,2'-bis(trifluoromethyl)-4,4'-diaminobiphenyl was applied to a 50 μm-thick triacetylcellulose (TAC) film and dried at 100°C for 10 minutes so that a transparent film was obtained in which the residual solvent content was 7% by weight, its thickness was 6 μm, nα was about 0.04, Rz was 240 nm, and nx≈ny. The transparent film was then subjected to lengthwise uniaxial stretching by 5% at 160°C together with the TAC film. The transparent film was then separated from the TAC film so that a birefringent film having the characteristic nx>ny>nz was continuously produced. Re and Rz of the birefringent film and the tilt of the orientation axis with respect to the in-plane molecular orientation (accuracy) were as follows: Re(nm)=50 nm, Rz(nm)=180 nm, orientation axis tilt (degree)=±0.3.

[0144]

<Birefringent Film (2)>

A birefringent film having an integrated TAC substrate was obtained using the process of preparing Birefringent Film (1) except that the substrate to be coated was an 80 μm-thick TAC film on which a 0.1 μm-thick modified polyurethane resin layer (Vylon UR-1400 manufactured by Toyobo Co., Ltd.) had been previously formed

as an adhesion-promoting layer and that the polyimide solution was applied to the adhesion-promoting layer. Re and Rz of the birefringent film and the tilt of the orientation axis with respect to the in-plane molecular orientation (accuracy) were as follows: Re(nm)=55 nm, Rz(nm)=245 nm, orientation axis tilt (degree)=±0.3.

[0145]

Example 1

(Optical Film)

A TAC film (80 μm in thickness) serving as a protective film was laminated to both sides of the complex type absorbing polarizer with a water-soluble adhesive to form a complex absorbing polarizing plate. The TAC film had the following characteristics: in-plane retardation Re_1: 4 nm and thickness-direction retardation Rth: 60 nm. Birefringent Film (1) was adhered with an acrylic pressure-sensitive adhesive to one side of the resulting complex absorbing polarizing plate to form an optical film.

[0146]

(Liquid Crystal Display)

A VA mode liquid crystal cell was used and laminated with an acrylic pressure-sensitive adhesive to the optical film such that the Birefringent Film (1) side of the optical film faced the light incidence side of the liquid crystal cell. A single piece of the complex absorbing polarizing plate prepared as described above was laminated with an acrylic pressure-sensitive adhesive to the opposite side (viewer side) of the liquid crystal cell.

[0147]

Example 2

(Optical Film)

A TAC film (80 μm in thickness) serving as a protective film was laminated to one side of the complex type absorbing polarizer, and the TAC substrate side of Birefringent Film (2) was laminated to the other side, using a water-soluble adhesive in each case, so that an optical film was obtained.

[0148]

(Liquid Crystal Display)

A VA mode liquid crystal cell was used and laminated with an acrylic pressure-sensitive adhesive to the optical film such that the Birefringent Film (2) side of the optical film faced the viewer side of the liquid crystal cell. A single piece of the complex absorbing polarizing plate prepared as described above was laminated with an acrylic pressure-sensitive adhesive to the opposite side (light incidence side) of the liquid crystal cell.

[0149]

Example 3

(Liquid Crystal Display)

A VA mode liquid crystal cell was used and laminated with an acrylic pressure-sensitive adhesive to the optical film of Example 2 such that the Birefringent Film (2) side of the optical film faced the light incidence side of the liquid crystal cell. A commercially available polarizing plate (NPF-SEG1425DU manufactured by NITTO

DENKO CORPORATION) was laminated with an acrylic pressure-sensitive adhesive to the opposite side (viewer side) of the liquid crystal cell.

[0150]

Comparative Example 1

(Optical Film)

A polarizer was prepared in the same manner as described above, except that the liquid-crystalline monomer was not used in the preparation of the complex type scattering-dichroic absorbing polarizer. Using the resulting polarizer, a polarizing plate was prepared in the same manner as describe above. An optical film was also prepared using the process of Example 1, except that the resulting polarizing plate was alternatively used.

[0151]

(Liquid Crystal Display)

A VA mode liquid crystal cell was used and laminated with an acrylic pressure-sensitive adhesive to the optical film such that the birefringent film (1) side of the optical film faced the light incidence side of the liquid crystal cell. A single piece of the polarizing plate prepared as described above was laminated with an acrylic pressure-sensitive adhesive to the opposite side (viewer side) of the liquid crystal cell.

[0152]

Comparative Example 2

(Liquid Crystal Display)

A VA mode liquid crystal cell was used, and the polarizing plates obtained in Comparative Example 1 were laminated with an acrylic pressure-sensitive adhesive to both sides of the liquid crystal cell.

[0153]

(Evaluation)

Polarizing plates obtained in Example 1 and Comparative example 1 were measured for optical properties using a spectrophotometer with integrating sphere (manufactured by Hitachi Ltd. U-4100). Transmittance to each linearly polarized light was measured under conditions in which a completely polarized light obtained through Glan Thompson prism polarizer was set as 100%. Transmittance was calculated based on CIE 1931 standard colorimetric system, and is shown with Y value, for which relative spectral responsivity correction was carried out. Notation k_1 represents a transmittance of a linearly polarized light in a maximum transmittance direction, and k_2 represents a transmittance of a linearly polarized light perpendicular to the direction.

[0154]

A polarization degree P was calculated with an equation $P = \{(k_1 - k_2) / (k_1 + k_2)\} \times 100$. A transmittance T of a simple substance was calculated with an equation $T = (k_1 + k_2) / 2$.

[0155]

Furthermore, polarizers obtained in Example 1 and

Comparative example 1 were measured for a polarized light absorption spectrum using a spectrophotometer (manufactured by Hitachi Ltd. U-4100) with Glan Thompson prism. Fig. 2 shows polarized light absorption spectra of polarizers obtained in Example 1 and Comparative example 1. "MD polarized lights" in Fig. 2 (a) represent polarized light absorption spectra when a polarized light with a plane of vibration parallel to a stretching axis enters, and "TD polarized lights" in Fig. 2 (b) represent polarized light absorption spectra when a polarized light with a plane of vibration perpendicular to a stretching axis enters.

[0156]

In TD polarized lights (= transmission axis of polarizer), in visible range whole band, while absorbance of the polarizers in Example 1 and Comparative example 1 showed almost equal value, in MD polarized lights (= absorption of polarizer + scattering axis), absorbance in the polarizer of Example 1 exceeded absorbance of the polarizer in Comparative example 1 in shorter wavelength side. That is, the above-mentioned result shows that light polarizing performance of the polarizer in Example 1 exceeded performance of the polarizer in Comparative example 1 in a short wavelength side. Since all conditions, such as stretching and dyeing, are equivalent in Example 1 and Comparative example 1, it is thought that orientation of iodine based light absorbing materials is also equivalent. Therefore, as mentioned above, a rise of absorbance in MD polarized light of the polarizer of Example 1 shows that

light polarizing performance improved by an effect caused by an effect of anisotropic scattering having been added to absorption by iodine.

[0157]

In haze values, a haze value to a linearly polarized light in a maximum transmittance direction, and a haze value to a linearly polarized light in an absorption direction (a perpendicular direction). Measurement of a haze value was performed according to JIS K7136 (how to obtain a haze of plastics-transparent material), using a haze meter (manufactured by Murakami Color Research Institute HM-150). A commercially available polarizing plate (NPF-SEG1224DU manufactured by NITTO DENKO CORP.: 43% of simple substance transmittances, 99.96% of polarization degree) was arranged on a plane of incident side of a measurement light of a sample, and stretching directions of the commercially available polarizing plate and the sample (polarizer) were made to perpendicularly intersect, and a haze value was measured. However, since quantity of light at the time of rectangular crossing is less than limitations of sensitivity of a detecting element when a light source of the commercially available haze meter is used, light by a halogen lamp which has high optical intensity provided separately was made to enter with a help of an optical fiber device, thereby quantity of light was set as inside of sensitivity of detection, and subsequently a shutter closing and opening motion was manually performed to obtain a

haze value to be calculated.

[0158]

Table 1

	Transmittance of linearly polarized light (%)		Single substance transmittance (%)	Polarization degree (%)	haze value (%)	
	Maximum transmission direction (k_1)	Perpendicular direction (k_2)			Maximum transmission direction	Perpendicular direction
Example 1	87.00	0.035	43.53	99.92	1.8	82.0
Comparative Example 1	87.00	0.043	43.52	99.90	0.3	0.2

[0159]

Table 1 shows that the polarizing plate in each of the example and the comparative example has good polarization properties such as a high single substance transmittance and a high degree of polarization. In the example, the polarizing plate uses a polarizer having a structure that includes a matrix formed of an optically-transparent water-soluble resin containing an iodine based light-absorbing material and minute domains dispersed in the matrix. Thus, it is apparent that the haze value with respect to the transmittance in the perpendicular direction is higher in the example than in the comparative example where the polarizing plate uses a conventional polarizer and that the unevenness caused by uneven transmittance is concealed by scattering so that it cannot be detected in the example.

[0160]

The liquid crystal display obtained in each of Examples and Comparative Examples was evaluated as described below. The results are shown in Table 2.

[0161]

70° Contrast Ratio: The liquid crystal display was placed on a backlight, and the contrast ratios in the vertical (normal) direction and in an oblique direction making an angle of 70° with the normal direction with an angle of 45° with respect to the optical axes of the crossed polarizing plates were measured using EZcontrast manufactured by ELDIM.

[0162]

Unevenness: A level at which the unevenness was visually detectable was represented by the mark "×", while a level at which the unevenness was not visually detectable was represented by the mark "○."

[0163]

Table 2

	Vertical Contrast	70° Contrast	Unevenness
Example 1	550	31	○
Example 2	570	32	○
Example 3	590	30	○
Comparative Example 1	600	29	×
Comparative Example 2	320	12	○

[0164]

The results of Table 2 indicate that in contrast to the comparative examples, the unevenness caused by uneven transmittance is concealed by scattering in the examples, and relatively high contrast ratios and improved visibility are obtained in the examples.

[0165]

As a complex type scattering-dichroic absorbing polarizer having a similar structure as a structure of a polarizer of this invention, a polarizer in which a mixed phase of a liquid crystalline birefringent material and an absorption dichroism material is dispersed in a resin matrix is disclosed in Japanese Patent Laid-Open No.2002-207118, whose effect is similar as that

of this invention. However, as compared with a case where an absorption dichroism material exists in dispersed phase as in Japanese Patent Laid-Open No.2002-207118, since in a case where an absorption dichroism material exists in a matrix layer as in this invention a longer optical path length may be realized by which a scattered polarized light passes absorption layer, more scattered light may be absorbed. Therefore, this invention may demonstrate much higher effect of improvement in light polarizing performance. This invention may be realized with simple manufacturing process.

[0166]

Although an optical system to which a dichroic dye is added to either of continuous phase or dispersed phase is disclosed in Japanese Patent Laid-Open No.2000-506990, this invention has large special feature in a point of laminating a complex type absorbing polarizer and a birefringent film imparted the characteristic nx>ny>nz, especially this invention has large special feature in a point of using iodine as an absorption dichroism material of the complex type absorbing polarizer. The following advantages are realized when using not dichroic dye but iodine. (1) Absorption dichroism demonstrated with iodine is higher than by dichroic dye. Therefore, polarized light characteristics will also become higher if iodine is used for a polarizer obtained. (2) Iodine does not show absorption dichroism, before being added in a continuous phase (matrix

phase), and after being dispersed in a matrix, an iodine based light absorbing material showing dichroism is formed by stretching. This point is different from a dichroic dye having dichroism before being added in a continuous phase. That is, iodine exists as iodine itself, when dispersed in a matrix. In this case, in general, iodine has a far effective diffusibility in a matrix compared with a dichroic dye. As a result, iodine based light absorbing material is dispersed to all corners of a film more excellently than dichroic dye. Therefore, an effect of increasing optical path length by scattering anisotropy can be utilized for maximum, which increases polarized light function.

[0167]

A background of invention given in Japanese Patent Laid-Open No.2000-506990 describes that optical property of a stretched film in which liquid droplets of a liquid crystal are arranged in a polymer matrix is indicated by Aphonin et al. However, Aphonin et al. has mentioned an optical film comprising a matrix phase and a dispersed phase (liquid crystal component), without using a dichroic dye, and since a liquid crystal component is not a liquid crystal polymer or a polymerized liquid crystal monomer, a liquid crystal component in the film concerned has a sensitive birefringence typically depending on temperatures. On the other hand, this invention provides a polarizer comprising a film having a structure where minute domains are dispersed in a matrix formed of an optically-

transparent water-soluble resin including an iodine based light absorbing material, furthermore, in a liquid crystalline material of this invention, in the case of a liquid crystal polymer, after it is orientated in a liquid crystal temperature range, cooled to room temperatures and thus orientation is fixed, in the case of a liquid crystal monomer, similarly, after orientation, the orientation is fixed by ultraviolet curing etc., birefringence of minute domains formed by a liquid crystalline material does not change by the change of temperatures.

Industrial Applicability

[0168]

The optical film of the invention is suitable for use alone or in the form of a laminate with any other optical film in image displays such as liquid crystal displays, organic EL displays, CRTs, and PDPs.